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Synthesis and characterization CdS based thin films as an energy storage device

V.Hariharan and V.N. Vijayakumar

Department of Physical Science, Bannari Amman Institute of Technology, Sathyamangalam, TN, India.

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ABSTRACT

Thin film patterned CdS is considered to be as the most promising semiconducting materials among various structures because of its tunable physical properties which leads the material to the recent applications such as solar cells, sensors, hydrogen storage devices, modulators etc. Moreover, in order to form CdS thin films chemical bath deposition techniques is one of the easiest method among various techniques. It is due to the fact that it has many advantages such as simplicity, no requirements for sophisticated instruments, minimum wastage, economical way of large area deposition, no need of handling poisonous gases and possibility of room temperature depositions. With these advantages in mind an attempt has been made to deposit device quality CdS thin films at various temperatures by CBD technique. The thicknesses of the deposited films have been determined by gravimetry. The structural characterization is carried out by X-ray diffraction. The study confirms the polycrystalline nature of films with hexagonal structure. The structural parameters such as grain size, dislocation density, strain and lattice parameters have been evaluated. The composition of various constituents in CdS films have been determined by energy dispersive X-ray analysis. The optical properties like optical transmittance, band gap and refractive index has been studied in detail for the CdS films of various thicknesses.

Introduction

With these advantages in mind an attempt has been made to deposit device quality CdS thin films at various temperatures by CBD technique. In earlier days the CBD technique was mainly used for preparing nano crystalline semi conducting thin films and widely used for depositing metal selenides [1]. In CBD the film formation occurs when the ionic product exceeds the solubility product as reported in the preliminary studies by B.R.Sankapal et al., [2] and Bhattacharya [3]. So a systematic study has been carried out for CdS films prepared at various temperatures. This paper deals with structural and optical properties of chemically deposited CdS films at the temperatures 60^0 C and 70^0 C with the composition of $CdCl_2$ in aqueous solution 0.2 gm and 0.3 gm. The optical absorption edge shifts towards lower photon energies as the air-annealing temperature raises in the controlled condition of above mixture (cadmium salt and thiourea concentrations) which was demonstrated by C. Guillen and his co-workers [4]. Copper indium diselenide thin films of different thicknesses were prepared by M. Dhanam et al [5] through the chemical bath deposition technique also found that the optical properties have been studied in detail in the wavelength range 4000–14500 Å and the optical band gap has been found to be direct and allowed.

Experimental procedure

CdS thin films are prepared using cadmium chloride, thiourea, liquid ammonia and triethanolamine as the raw materials. The mixture containing totally 29 ml i.e., 0.2 gm of $CdCl_2$ dissolved in 10 ml distilled water, 0.7612 gm of Cs $(NH^2)_2$ dissolved in 10 ml distilled water and these two are dissolved in 5 ml liquid ammonia and 4 ml triethanol amine. The solution is mixed thoroughly and carefully. The common complexing agent ammonia is used as mediator and triethanol ammine is used to ensure slow release of Cd^{2+} ions in the deposition mixture. The reduction or oxidation reaction is described below,

$$CdCl_{2\,(aq)} + CS(NH_2)_{2\,(aq)} + 2OH^-_{(aq)} \longrightarrow CdS_{(solid)} + CNNH_{2\,(aq)} + 2HCl_{(liquid)} \text{ ------1}$$

Optical glass slide with thickness of 1.25 mm are used as substrates. Prior to deposition the substrates have been cleaned with detergent solution, distilled water and acetone for about 30 minutes each in an ultrasonic bath to increase the rate of contamination removal and to achieve completeness. Finally the wet, cleaned substrates are dried in a clean oven maintained at about 90 ºC. Five substrates are suspended vertically in the solution maintained at 60 ^{0}C temperature using hot plate and stirred gently with a magnetic stirrer. The deposition takes place by homogeneous reaction in the solution and by heterogeneous at the substrate leading to the formation of the film [5]. The deposition is allowed to continue for one hour. The thickness of the films for a single dip will be of the order 1000 Aº. A maximum bath temperature is fixed at 70º in order to suppress the rate of homogeneous reaction and minimize the evaporation of ammonia from the chemical bath. The thicknesses of the deposited films have been determined by gravimetric method.

Results and discussions

The characteristic results show that the chemical bath deposition technique made CdS films of different thickness. X-ray diffraction reveals that the films are polycrystalline in nature with hexagonal structure. The variations in the particle size, strain dislocation density with temperature for different composition have been studied which confirms the role of temperature in the formation of CdS thin films. Using Transmittance spectra the optical band gap and the various optical parameters like absorption co-efficient, extinction co-

Tele:
E-mail addresses: vnvphysics@gmail.com

efficient and refractive index are determined which revealed the suitability of the materials for the optical applications (table given below) and the extension of the present work also will be discussed in detail.

S.No	Composition of $CdCl_2$ in aqueous solution gms	Coating Temperature ˚C	Thickness A˚	Band gap eV
1	0.2	60 70	1417 1450	2.54 2.51
2	0.3	60 70	1710 1740	2.5 2.48
3	0.4	60 70	1940 1960	2.45 2.44

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